NOVA SCHOOL OF SCIENCE & TECHNOLOGY

MEEC

Electronics for Micro-Systems

Individual Assignment Problems Solving Analysis [EN]

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1 Problem 1

1.1 Voltage Gain

Considering an ideal OPAMP working on the linear region, the following assumptions were made.

- $Z_{in} = +\infty$
- $Z_{out} = 0$
- $A_d = +\infty$
- $V_+ = V_-$

In order to obtain the value of $V_{out}(V_{in})$, it is necessary to get the circuit equations.

$$\begin{cases} i_t = \frac{V_-}{R_1} \\ V_x = V_- + R_2 \cdot i_t \\ V_{out} = V_x + R_3 \cdot i_3 \\ i_3 = i_t + i_4 = i_t + \frac{V_x}{R_4} \end{cases} \tag{1}$$

Where i_t is the current passing through R_1 and R_2, V_x is voltage between R_3 terminals. This results in the following equation.

$$V_{out} = \frac{R_1 R_4 + R_2 R_4 + R_3 (R_1 + R_2 + R_4)}{R_1 R_4} \cdot V_i \tag{2}$$

1.2 Input Current Bias

In order to calculate the impact of the current bias, a current supply is placed in parallel on the input terminals of the OPAMP. As shown in the figure

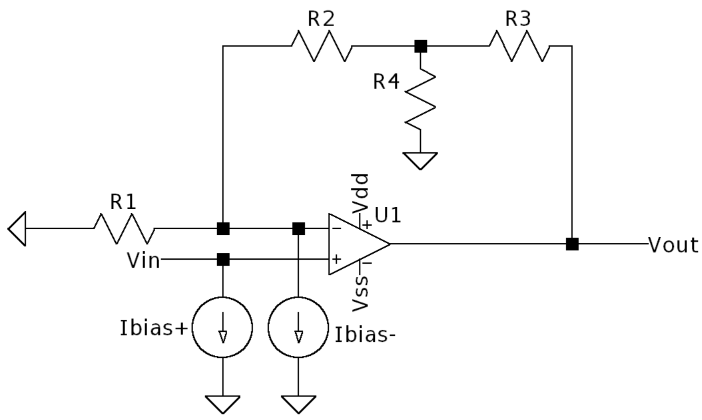

Figure 1: Circuit with input bias current

Using superposition, to evaluate the current effect on the output, the following system of equations is obtained.

$$\begin{cases} V_- = V_+ = 0 \\ I_{R_1} = 0 \\ \frac{V_x}{R_4} + \frac{V_x - V_{out}}{/} R_3 + I_{bias-} \\ V_{out} = I_{bias-} - \frac{V_x - V_{out}}{R_3} \end{cases} \tag{3}$$

The V_{Off} will only affect the saturation voltage of the circuit, will shift by the value of the V_{Off}, $Max \in [V_{Sat-} + V_{Off}, V_{Sat+} + V_{Off}]$

1.3 Voltage Input Range

Considering the total gain of the circuit A_d and the V_{Off} of the OpAmp, the maximum input voltage for this circuit will be:

$$V_{in} \in [\frac{V_{Sat-}}{A_d} + V_{Off}, \frac{V_{Sat+}}{A_d} + V_{Off}] \tag{4}$$

2 Problem 5

2.1 Considerations

- $T1 = 42\ C^\circ = 315.15\ K$
- $T2 = 42.5\ C^\circ = 315.65\ K$

2.2 NTC

Using the beta model:

$$R = R_0 e^{\beta\left(\frac{1}{T} - \frac{1}{T_0}\right)} \tag{5}$$

From the datasheet :

- $\beta = 3988$
- $R(25^\circ) = 5k\Omega$

Therefore:

$$R = 5K \cdot e^{3988 \cdot \left(\frac{1}{T} - \frac{1}{298.15}\right)} \tag{6}$$

Hence: R(T1) = R(T2) =

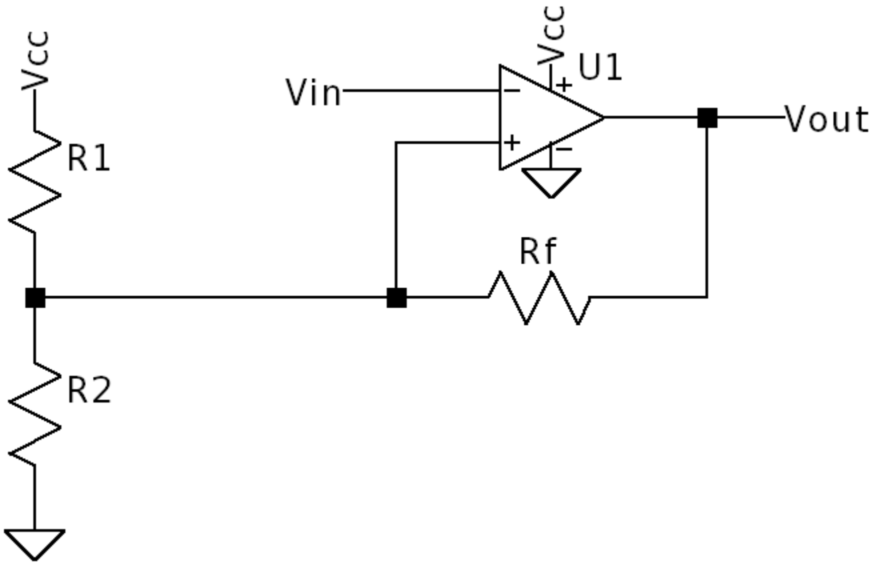

Figure 2: Comparator with hysteresis circuit [1]

For circuit dimensioning the following equations were used [2].

$$\begin{cases} \frac{R_f}{R_1} = \frac{V_L}{V_H - V_L} \\ \frac{R_2}{R_1} = \frac{V_L}{V_{CC} - V_H} \end{cases} \tag{7}$$

But since this circuit is inverting.

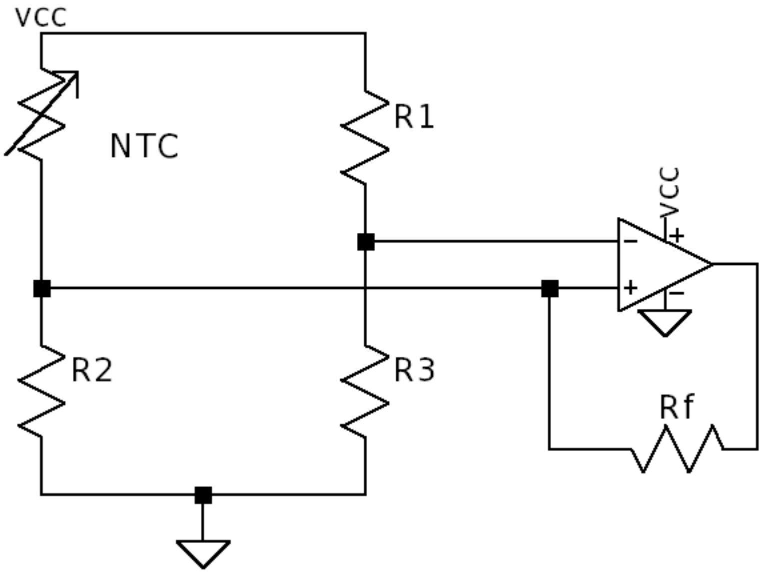

Figure 3: NTC with non-inverting comparator

In this circuit $V_{in} = V_{CC} \cdot \frac{R_3}{R_3+R_1}$, $R_1 = R_{NTC}$.

References

[1] TDK, "Ntc thermistors for temperature measuremen," https://product.tdk.com/system/files/dam/doc/product/sensor/ntc/ntc_element/data_sheet/50/db/ntc/ntc_mini_sensors_s861.pdf, 2018.

[2] A. Kay and T. Claycomb, "Comparator with hysteresis reference design," Texas Instruments, Technical Note TIDU020A, June 2014, revised Edition. [Online]. Available: https://www.ti.com/lit/ug/tidu020a/tidu020a.pdf